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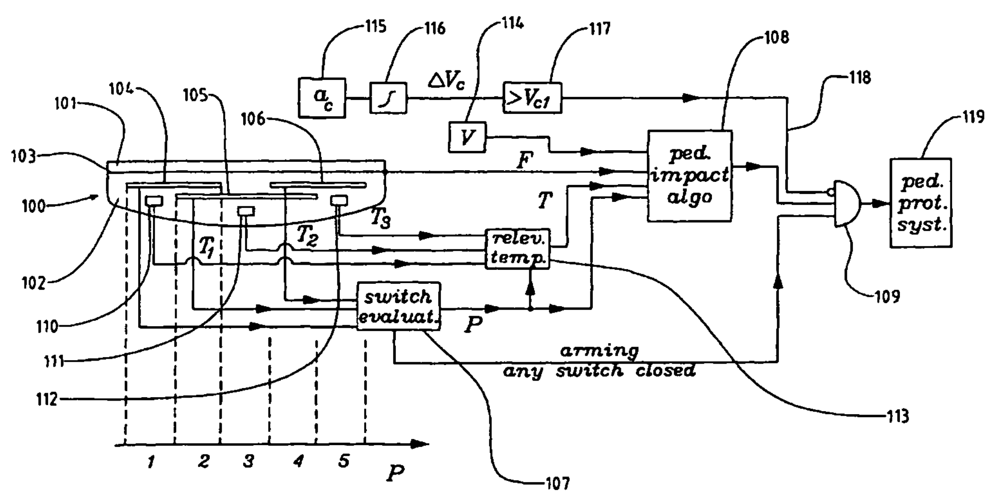
(54) Title: AN IMPACT DETECTOR SYSTEM



(57) Abstract: An impact detector for detecting and evaluating an impact and generating an output signal to deploy a pedestrian protection system (119) on a motor vehicle includes a sensor arrangement (101) to be mounted at the front of the vehicle to detect an impact. An eveluator (108) is provided to evaluate the output of the sensor and to generate an output signal when a predetrmined threshold is exceeded, so that the pedestrian protection system (119) is not actuated by an impact with a very light object. Additionally a chassis-mounted accelerometer (115) is provided to provide a signal indicative of the total deceleration applied to the vehicle. An inhibitor (109) is provided to inhibit generation of the signal that actuates the pedestrian protection system (119) if the output signal from the accelerometer (115) exceeds a predetermined threshold.

WO 03/082639 A1

"AN IMPACT DETECTOR SYSTEM"

THE PRESENT INVENTION relates to an impact detector system and more particularly relates to an impact detector system to be mounted on a motor vehicle to detect a particular kind of impact, such as, for example, an impact with a pedestrian.

It has been proposed to provide motor vehicles, such as motor cars, with safety devices intended to provide a degree of protection to a pedestrian that may be struck by the vehicle. One form of such a safety device includes an inflatable element having portions which extend up the "A"-Posts of the vehicle, to prevent the head of the pedestrian from being injured due to an impact with an "A"-Post of the vehicle. Another form of such a safety device lifts the rear part of the hood or bonnet of the vehicle, to distance the main region of the hood or bonnet from the underlying engine, thus enabling the hood or bonnet to deform if struck by the head of a pedestrian, consequently decreasing the risk of injury.

Prior proposed impact detectors have used different kinds of sensors in the bumper of a motor vehicle, such as accelerometers, deformation sensors and force sensors. An output signal to activate a safety device to protect a

pedestrian is generated if signals from the sensors are above or below predetermined threshold values.

In order to be able to discriminate an impact with a pedestrian from an impact with a lighter object, such as a bird, the sensor should ideally provide the output signal, in an accident situation in which an object is being struck, only in dependence upon a characteristic of the object being struck, such as the mass of that object, together possibly with other known and measurable parameters, such as the speed of the vehicle.

It is, of course, to be understood that it is often very inappropriate for a pedestrian protection device to be actuated in a severe accident, such as a collision with another vehicle. A pedestrian protection device may well obscure the view of the driver of the vehicle. If the pedestrian protection device is a device which raises the rear edge of the hood or bonnet, the rear part of the hood or bonnet may be driven through the windscreen or wind-shield, during the frontal collision, with the rear part of the hood or bonnet engaging with the driver and/or front seat passenger of the vehicle, causing undesirable injuries.

The present invention seeks to provide an improved impact detector system.

According to this invention there is provided an impact detector system for detecting an impact and generating an output signal to activate a pedestrian protection device on a motor vehicle, the system comprising at least one sensor to be mounted at the front of a vehicle to detect an impact, and an evaluator to evaluate the output of the sensor and to generate an output signal when a pedestrian detection criterion is fulfilled, the system incorporating an

accelerometer to provide a signal indicative of the total deceleration applied to the vehicle, the system incorporating an inhibitor to inhibit generation of the output signal if the signal from the accelerometer fulfills an inhibiting criterion.

Preferably, said accelerometer to provide a signal indicative of the total deceleration is located at a substantially central location on the vehicle.

Conveniently, the inhibiting criterion is fulfilled when a sliding-window mean value of the signal provided by the accelerometer exceeds a predetermined value.

Alternatively, said inhibiting criterion is fulfilled when the integrated value of the signal provided by the accelerometer exceeds a predetermined value.

Conveniently the sensor is configured to sense a variable that is dependent upon the nature of an impact, the sensor being mounted on or within an element adapted to be mounted on the front of a motor vehicle, the element having a deformable part with a predetermined stiffness, positioned to be deformed during an impact, the stiffness varying in accordance with at least one parameter, the detector incorporating an arrangement to measure the said at least one parameter, the said evaluator being configured to evaluate the output of the sensor in combination with a degree of stiffness corresponding to said at least one parameter as measured, and to generate said output signal when a predetermined threshold is exceeded.

Preferably the sensor is a force sensor.

Advantageously the sensor comprises at least one accelerometer mounted to the element, the element being provided with yieldable supports by means of which the element may be mounted on the front of a motor vehicle.

Preferably the sensor comprises two said accelerometers, and wherein the element is provided with two said yieldable supports, each accelerometer being provided located on or in a responsive yieldable support.

Conveniently the sensor comprises an elongate sensor mounted within the element, the sensor being located to have a force applied thereto when the deformable part of the element is deformed.

In one embodiment the sensor is a piezo-electric cable.

Conveniently there are a plurality of piezo-electric cables.

Conveniently piezo-electric cables partially overlap each other.

In another embodiment the sensor is at least one pressure tube.

Conveniently wherein there are a plurality of pressure tubes.

Advantageously wherein the pressure tubes partially overlap each other.

Conveniently each pressure tube is of non-uniform cross-section, having part of the cross-section of substantial vertical extent and part of the cross-section of lesser vertical extent.

Preferably wherein each pressure tube is provided with a vent hole.

Conveniently the deformable part of the element is formed of a deformable foam material.

Preferably the element incorporates a substantially rigid beam, the foam being mounted to the beam.

Advantageously the element is provided with at least one contact sensor, the detector including a logic arrangement so that said output signal is generated only when an output is provided by the evaluator and an output is provided by the said contact sensor.

Conveniently said at least one parameter comprises the thickness of the deformable part of the element, the deformable part of the element being of non-uniform thickness.

Preferably the arrangement to measure said at least one parameter comprises an arrangement to measure the point of impact and to determine the thickness of the said element in accordance with the point of impact.

Conveniently the means to measure the position of impact comprise an arrangement to compare the accelerations imparted to the two accelerometers, and to perform an algorithm.

Alternatively an analyser is provided to analyse signals from different piezo-electric cables to determine which cable or combination of cables is providing the signal, to determine the point of impact.

Alternatively an analyser is provided to analyse signals from different pressure tubes to determine which pressure tube or combination of pressure tubes is providing the signal, to determine the point of impact.

Preferably said at least one parameter includes temperature and wherein at least one temperature sensor is provided to sense temperature.

Conveniently wherein a plurality of temperature sensors are provided.

Advantageously the identity of the temperature sensor or temperature sensors providing an output signal used by the evaluator is determined by the means that determine the point of impact.

Advantageously the evaluator is configured additionally to evaluate a signal indicative of vehicle speed before the impact, the evaluator being configured to generate said output only when the vehicle speed is in excess of a first relatively low threshold and below a second relatively high threshold.

Conveniently the first threshold is 20 km per hour and the second threshold is 60 km per hour.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described by way of example with reference to the accompanying drawings in which:

FIGURE 1 is a diagrammatic view of a vehicle bumper provided with sensors in the form of accelerometers,

FIGURE 2 is a view of a vehicle bumper provided with a force sensor extending along the whole width of the bumper,

FIGURE 3 is a graphical figure provided for purposes of explanation,

FIGURE 4 is a further graphical figure provided for purposes of explanation,

FIGURE 5 is yet another graphical figure provided for purposes of explanation,

FIGURE 6 is a horizontal sectional view of a bumper incorporating two pressure tubes,

FIGURE 7 is a sectional view taken on the line VII-VII of Figure 6,

FIGURE 8 is a further diagrammatic view of a vehicle bumper, and

FIGURE 9 is a diagrammatic view of a vehicle bumper incorporated within a block diagram.

The stiffness of a member such as a vehicle bumper k defined as

$$k = F/s$$

where F is the force applied to a particular point or region of the bumper during an impact situation, and s is the actual displacement of the impact point or region. In a situation where there is an impact with an object having a mass m, with the speed of the vehicle on which the bumper is mounted immediately before the impact being v then, assuming that k is a constant,

$$s = v \,.\, \sqrt{\frac{m}{k}} \,.\, sin(\sqrt{\frac{k}{m}} \,.\, t)$$

If the deformation is not elastic (which might be considered to be normal in the case of a vehicle accident), then this equation is valid for a period of time t where

$$t \quad \leq \frac{\pi}{2}\sqrt{\frac{m}{k}}$$

Subsequently $s = s_{max} = v \,.\, \sqrt{\frac{m}{k}}$

If an accelerometer is used, the expression for acceleration is the second derivative of s:

$$a = v \,.\, \sqrt{\frac{k.}{m.}} \quad sin(\sqrt{\frac{k}{m}} \,.\, t)$$

The force $F = k.s$ and thus

$F(t) = v.\ \sqrt{k.m} \,.\, sin(\sqrt{\frac{k}{m}}\ .t\ )$ for

$t \leq \frac{\pi}{2}\sqrt{\frac{m}{k}}$ and

thereafter $F(t) = 0$.

The mathematical analysis set out above only refers to the actual point of impact. If a sensor is provided which is located behind the point of impact, the signal is reduced with a factor equal to the quotient between the total stiffness

and the stiffness behind the sensor, that is to say between the sensor and the chassis of a vehicle on which the member is mounted. To gain a high signal the stiffness in front of the sensor should be high and the stiffness behind the sensor should be low. However, to minimise the risk of injuring a pedestrian, the stiffness in front should be low. A good compromise can be achieved if the stiffness behind the sensor is less than $^1/_{10}$ of the total stiffness of the vehicle bumper.

Consequently it is to be understood that in the situation considered above, if the vehicle speed v immediately before the impact is known, and if the stiffness k for the vehicle bumper in the region where the impact occurs is known, it is possible to calculate m, the mass of the object with which the impact is occurring.

Of course, once the mass m of the object has been determined, that value can be used in an algorithm to determine whether or not the control signal for a safety device to protect a pedestrian should, or should not, be generated. The algorithm may, of course, rely on other parameters, such as the absolute vehicle speed, bearing in mind that a safety device to provide protection for a pedestrian may be considered to be effective only if the speed of impact with the pedestrian is greater than 20 km per hour, and less than 60 km per hour. At vehicle speeds less than 20 km per hour, or greater than 60 km per hour, most present-day safety devices intended to provide protection for pedestrians are thought to have no tangible beneficial effect.

Referring initially to Figure 1 of the accompanying drawings, a bumper (or fender)assembly 1 is mounted to the front part of a motor vehicle 2, such as a motor car, by two yieldable supports 3, 4 which are each located adjacent a respective end of the bumper. Each support 3, 4 may be in the form of a

generally tubular housing formed of material having a thickness such that the housing will collapse or yield during a typical impact situation involving a pedestrian. Each support may thus be considered to be a "crash box".

Mounted on the rear part of the bumper 1 are two accelerometers 5, 6. The accelerometer 5 is mounted within the "crash box" 3 and the accelerometer 6 is mounted within the "crash box" 4, so that the respective crash boxes can provide a degree of protection for the accelerometers. However, the accelerometers may be positioned on the crash boxes or anywhere adjacent the crash boxes, possibly within part of the bumper assembly itself. In the described embodiment each accelerometer is mounted to the rear face of a relatively stiff beam 7 which forms part of the bumper 1. The front face of the beam 7 is provided with a yieldable covering 8 constituted, in the illustrated arrangement, by a "foam" block which is secured to the front face of the beam 7. The foam is a yieldable foam, the foam being of a uniform construction and thus having a known degree of "stiffness".

The foam does not have a uniform thickness, however, and thus the absolute stiffness of the foam at any particular point is dependent upon the thickness of the foam at that particular point.

The stiffness of the foam at any particular position or point could be calculated from design data, and the calculated stiffness could be stored in a memory in the form of a "look-up table". Thus, as will become clear from the following description, it would be possible to calculate the position of the point of impact and then to determine the relevant stiffness, from the "look-up" table for that position.

Should an impact with a pedestrian occur, such that a force, as indicated by the arrow F is applied to a specific point, such as point 9 on the bumper, then if the distance between the two accelerometers is l_0 and the distance between the point of impact 9 and the first accelerometer 5 is l_A, it will be found that the accelerometer 5 will provide an output signal a_A and the second accelerometer 6 will provide an output signal a_B, the output signal being representative of a force F_A applied to the first accelerometer 5, and a force F_B applied to the second accelerometer 6 where $F = F_A + F_B$. It is possible to determine the precise location of the point 9 relative to the accelerometers 5 and 6 because

$$l_A \approx \frac{l_0 \, . \, a_B}{a_A + a_B}$$

Having determined the precise position 9 at which the impact occurred, by analysing the output signals a_A and a_B from the accelerometers 5 and 6, it is possible to determine the stiffness of the foam 8 at that position, using stored data about the bumper, and consequently, relying on the mathematical analysis set out above, it is possible to determine the mass of the impacting object. Thus the algorithm used relies on the stiffness k of the foam, and on the stiffness of the "crash boxes" 3, 4. Thus the stiffness of elements in front of and behind the sensors are utilised.

Figure 2 illustrates a bumper 11 mounted to the front of the vehicle 12 by means of yieldable supports, or "crash boxes" 13, 14 of the type described above, located adjacent the opposed ends of the bumper 11. The bumper includes a substantially rigid beam 15 which extends between the supports 13 and 14, and, mounted to the front of the beam, is a foam element 16. Between the foam element and the beam is a sensor element 17, the sensor element either being in the form of a pressure tube or being in the form of a piezo-cable. The

sensor is responsive to the total force applied to the bumper, regardless of the precise point at which the force is applied.

A pressure tube is a tube having yieldable walls and containing a gas or liquid. The gas or liquid is in communication with a pressure sensor. If a force is applied to the tube, deforming the tube, the pressure of the gas or liquid rises, and this rise in pressure is sensed by the pressure sensor.

A piezo-cable is an elongate cable having an elongate piezo-electric material between two elongate electrodes. A piezo-electric material is a material which, when compressed, generates an electric potential across opposed faces thereof. Thus the cable is such that if a force is applied to the cable, a potential is created, and that potential may be sensed. The piezo-electric material utilises a dielectric material with good piezo-electric properties.

In some forms of piezo-cable, the piezo electric material is divided up into a plurality of small segments, there being individual electrodes associated with each segment, such that an output generated by the piezo-cable automatically indicates the precise point at which a force is applied to the cable. Thus such a cable may immediately identify a point of impact. Where, however, a pressure tube is used, the pressure tube could be divided into separate segments, which might overlap, or, alternatively a separate position sensor could be utilised to determine the position of the impact since, in the illustrated embodiment, the foam 16 is not of uniform thickness, and thus does not have a uniform overall stiffness characteristic and, as in the previously described embodiment, it will be appropriate to determine the position of impact so that the relevant stiffness may be determined for the point of impact from the stored information relating to the bumper.

If the effective stiffness k_1 at a substantially central point of the bumper of Figure 2 (where the foam is quite thick) is considered, the effective stiffness k_1 relies on the stiffness of the foam k_{1f} at the relevant substantially central point and also the stiffness k_{1b} of the beam 15 at the relevant substantially central point, and may be expressed as:

$$k_1 = \frac{k_{1f} \cdot k_{1b}}{k_{1f} + k_{1b}}$$

Because the beam is "softer" at a position between the supports 13, 14, k_{1b}, the effective stiffness of the beam at a point between the supports is less than k_{2b} the effective stiffness of the beam adjacent one of the supports 13. Also it is to be noted that k_{1f} is much less than k_{2f}, a point adjacent a support 13, because the foam is "softer" where it is thicker.

Turning now to Figure 3, various plots of detected force as compared with time are shown for different combinations of m, k and v.

As has been mentioned above, for designs and materials which have a constant stiffness ($k = F/s$):

$$F(t) = v\,\sqrt{k.m.}\;sin(\sqrt{\frac{k}{m}}\;.\;t)$$

$$\text{for}\quad t < \frac{\pi}{2}\sqrt{\frac{m}{k}}$$

The first line plotted in Figure 3, namely line 21, shows a typical force against time line for an impact with an object having a mass m_1 with a vehicle velocity of v_1, the central part of the beam of Figure 2, where the effective stiffness is k_1. The line rises gradually towards a maximum and then drops suddenly at the end

of the impact situation. Line 22 illustrates a similar situation to that of line 21, but the velocity v_2 has been increased. It can be seen that the line has a steeper initial path, rising to a greater maximum force, but terminates at substantially the same instant as line 21.

Line 23 illustrates the force experienced at the vehicle speed v_1 for an impact with an object having a mass m_1, in a region of effective stiffness k_2 as shown in Figure 2, adjacent a support 13 for the bumper 11. Again the overall shape of the line is similar to that described above, with the line rising towards a maximum force and then terminating abruptly. However, the maximum force is less than that for lines 21 or 22, but the time at which the force drops is later, as compared with the commencement of the force.

Finally, line 24 illustrates the force experienced during an impact at a vehicle speed v_1 with an object having a mass m_2 where m_2 is greater than m_1, again at a region where an effective stiffness k_2 is experienced. The line 24 rises gradually to a maximum and then terminates abruptly. The maximum, however, is greater than the maximum seen in line 23, and the termination of the force occurs at a later instant than it does in line 23.

Turning now to Figure 4, it is possible to use a set of criteria for generation of the control signal for the safety device which include the mass of the struck object and the speed of the vehicle.

Figure 4 is a graphical figure indicating a plot between applied force and absolute vehicle speed. As mentioned above, it may be appropriate to select a predetermined range of vehicle speeds so that the control signal is only generated if the vehicle speed, before the impact, is within the selected range. In Figure 4 the range of 20 km to 60 km per hour has been selected, but this is

an arbitrary selection. If an impact is detected while the vehicle is travelling within the speed range the control signal should only be generated if the force F exceeds a threshold.

$$F_1 \geq v.\ \sqrt{k.m_1}$$

where m_1 is the lower limit of the mass of the leg of a pedestrian.

Consequently, it is possible to draw a line having a slope $\frac{dF_1}{dv} = \sqrt{k.m_1}$ and such a line has been plotted on the graph as line 30. Thus, if the mass of an object struck during any particular impact is such that a force is generated which is found in the area of 31 located above the line 30, then the output signal should be generated.

If a foam, or equivalent material is used, at least a part of the path from the position of the point of impact to the chassis of the vehicle will have a stiffness k which will be dependent on temperature as normally foam gets softer, with a lower k value at the temperature rises.

For many materials or designs the stiffness k is not independent of s, a or F. The stiffness k could also be dependent on v.

If, for example $F = f_1(k, v, m)$ where $k = f_2(F, v, T)$, then F could be written as a new function of f_3.

$F = f_3(T, v, m)$ where f_3 is independent of F. For the sake of simplicity it is assumed that for this analysis k is independent of the position of impact.

Figure 5 shows different plots of $F(t)$ for foam used in bumpers for different T and thus different k but with the same values for v and m.

The first line 40 appearing in Figure 5 illustrates the effect with a relatively low temperature $T1$ and thus with a relatively high stiffness k_1. The total time taken for completion of the illustrated cycle is relatively short. For a higher temperature $T2$ and thus a lower foam stiffness k_2, as shown at line 41, the total time taken is much longer but the maximum force is lower than for the line 40. The integral of the line 40 (i.e. the area under the curve) is the same as that for the line 41.

Referring now to Figures 6 and 7 of the accompanying drawings, a further bumper 51 is illustrated secured to the chassis 52 of a motor vehicle by means of two yieldable supports which may be in the form of crash boxes 53, 54. The bumper is provided with a relatively stiff rear beam 55, carrying, on its front face, a foam element 56. The foam element 56 of the illustrated embodiment has formed within it a channel constituting two adjacent pressure tubes 57, 58. The pressure tubes are identical and thus only the pressure tube 58 will be described. The pressure tube 58 comprises an elongate tube, there being a pressure sensor 59 within the tube providing an output on an output lead 60 to a processor 61. Each tube may be a channel formed in the foam material. The walls of the channel may be sealed and such sealing will be necessary if the foam is an open cell foam. The tube is provided with a vent hole 61 to atmosphere so that the tube normally contains air at atmospheric pressure. As can be seen most clearly from Figure 7, the interior of the tube does not have a uniform cross-section, but instead has a "trapezoidal" cross-section, the cross-section having a substantial dimension towards the very front of the bumper, and having a reducing section towards the rear of the bumper. The reason for this is that if such a tube is compressed, the change in volume, in

the part of the tube which has the greater "height", is large relative to the total volume of the chamber.

It is preferred to use two or more individual tubes, rather than one single tube, because the effective reduction of volume, as compared with the total volume, is much greater for a smaller tube extending across only part of the length of the bumper, than for a longer tube extending across the whole length of the bumper in any specific impact situation. If a plurality of tubes are used by "overlapping" the tubes, it may be possible to determine the point of impact by determining which tubes have been subjected to an increase in pressure, thus enabling the effect of the thickness of the foam at the point of impact to be taken into account. A similar effect may be achieved by "overlapping" a plurality of piezo-cables of the type discussed above.

It is thought that in preferred embodiments of the present invention, it will be beneficial to have an independent "arming" arrangement which must be actuated before the control signal to deploy the safety device can be generated. Such an arrangement will minimise the risk of the control signal being generated in an inappropriate situation due, for example, to a single spurious electric signal.

Figure 8 illustrates a bumper 71 mounted to the chassis 72 of the motor vehicle by yieldable supports 73, 74 which may be in the form of "crash boxes" positioned adjacent the ends of the bumper 71. The bumper 71 incorporates a beam 75. On the front of the beam 75 is a body 76 formed of a yieldable foam. Incorporated within the foam body is a force sensor 77 in the form of one or more pressure tubes, or in the form of one or more piezo-cables. The sensor 77 provides an output signal shown schematically as the output 78.

In front of the sensor 77 is a totally separate and independent contact sensor 79. The contact sensor 79 may simply comprise two electrically conductive foils which initially are spaced a very short distance apart within the foam. Should any force be applied to the foam 76, the foils will be brought into electrical contact, thus effectively "shorting out", electric leads 80, 81 which are connected to the two foils. Other forms of contact sensor may be utilised, and it will be understood that before the control signal may be generated, firstly the contact sensor 79 must sense contact and, secondly in the manner described above, it must be determined that the mass of the object with which an impact is occurring meets the appropriate criteria. The contact sensor may include overlapping contact sensor elements to assist in the determining the position of the point of impact, as will be described more fully below.

Reference has been made to relying on the effective stiffness of the material forming a bumper, and the stiffness of the mounts which mount the bumper in position, in calculations to determine the mass of an object striking the bumper. The stiffness of the material forming the bumper may be dependent upon temperature. Thus, in the bumper shown in Figure 8, a temperature sensor 82 is incorporated within the foam body providing an output 83, and the output 83 may be fed to the processor so that in performing any calculations which relate to the stiffness of the foam body, appropriate adjustments may be made in accordance with the actual temperature. However, in an embodiment which incorporates a piezo-cable, as described above, the capacitance between the electrodes of the cable , which varies as a function of temperature, may be measured and analysed to provide a signal representative of temperature.

Figure 9 illustrates a complete operative system forming a preferred embodiment of the invention.

Figure 9 shows a bumper 100 which may be mounted on a motor vehicle in the manner discussed above, using two supports in the form of "crash boxes" adjacent the ends of the bumper. The bumper 100 incorporates a relatively rigid beam 101, to the front face of which is mounted a foam body 102. A force sensor 103 is provided between the foam body 102 and the beam 101, which may be in the form of a plurality of pressure tubes, or a piezo-cable. In the embodiment of Figure 9, three elongate contact sensors 104, 105, 106 are provided, which are overlapping. The contact sensors 104, 105, 106 are within the foam body 102, being positioned in front of the force sensor 103. The rear-most contact sensors 104, 106 are spaced-apart, and the forward contact sensor 105 overlaps substantially half of each of the contact sensors 104, 106, and also extends across the space between the contact sensors 104 and 106. This relatively simple arrangement enables five discrete contact zones to be identified, using only three sensors.

As can be seen, if an impact occurs to the very left of the bumper as shown in Figure 9, it is only the contact sensor 104 that will sense contact. If the impact occurs slightly to the right, where the sensor 104 overlaps the sensor 105, both sensors will detect an impact. If the impact occurs even further to the right, only the middle sensor 105 will detect the impact, unless the impact occurs at a point where the sensor 105 overlaps the sensor 106, in which case both the sensors will sense the impact. Finally, should the impact occur at the very right-hand side of the bumper, only the sensor 106 will detect the impact. The sensors 104, 105, 106 are all connected to an evaluation unit 107 which determines which sensor or which combination of sensors have sensed contact, and provides an appropriate output signal indicative of the point where the

impact has occurred to a processor 108 which carries out a pedestrian impact algorithm. The processor 108 is configured to determine, from a "look up table" stored in a memory the effective stiffness of the foam in the relevant zone. If any one of the contact sensors senses a contact, then an arming signal is provided to a logic component in the form of an inhibitable "AND gate" 109, which also receives an input from the processor 108.

In the embodiment illustrated a plurality of temperature sensors 110, 111 and 112 are provided within the bumper. The temperature sensors sense the temperature in different regions of the foam body 102. The output signal from the evaluation unit 107 is passed to a temperature selection unit 113 which receives signals from the three temperature sensors 110, 111 and 112. Depending upon the determination as to the point of impact from the evaluation unit 107, the temperature of an appropriate temperature sensor, or of a combination of temperature sensors, is passed, by the temperature selection unit 113 to the processor 108 carrying out the pedestrian impact algorithm. The actual temperature may be used to adjust the selected value of stiffness appropriately.

The processor 108 also receives an input indicating the speed of the vehicle immediately preceding the impact from the vehicle speedometer unit 114.

In the embodiment as shown in Figure 9, a further accelerometer 115 is provided which is mounted on the main chassis of the vehicle, preferably at a central location. The accelerometer 115 is therefore responsive to the total acceleration of the vehicle, and, as will become clearer, this accelerometer is utilised to determine if the vehicle has been involved in an impact with a very

heavy object, such as another vehicle, in which case it would be inappropriate to deploy the safety device intended to provide protection for a pedestrian.

The output of the accelerometer 115 is integrated at an integrator 116, to provide a signal representative of the total velocity change of the vehicle during a predetermined period of time.

$$\int_{t_0}^{t} a_c \, . \, dt$$

The output of the integrator is fed to a discriminator 117. The discriminator is intended to determine whether the change in velocity is such that an impact has occurred with an object which is much heavier than a pedestrian. Should the discriminator 117 determine that the change in velocity exceeds a predetermined threshold, which may indicate that an impact has occurred with an object heavier than a pedestrian, then a signal is generated on lead 118 which inhibits the AND-gate 109, thus preventing the control signal on the output of the AND-gate from being generated.

Instead of calculating the total velocity change a low pass filter could be applied to the acceleration signal, or a "sliding window" mean value may be calculated, this being the mean value, at any instant, over a preceding predetermined period of time.

$$\frac{1}{\Delta t} \int_{t-\Delta t}^{t} a_c \, . \, dt$$

The output of the AND-gate 109 is provided to the safety device in the form of a pedestrian protection system 119.

It is, therefore, to be appreciated that in the event of an impact which causes a force to be applied to part of the bumper 100, initially the force is detected by one or more of the contact detectors 104, 105, 106, which will enable the evaluation unit 107 to determine which area of the bumper has been struck and pass that information to the processor 108, and also to provide an arming signal to the AND-gate 109. Also, the evaluation unit 107 will be able to pass an appropriate signal to the temperature selection unit 113 to enable an appropriate temperature signal to be passed to the processor 108.

The force of the impact will be measured by the force sensor 103 and the appropriate force will be passed to the processor 108. The processor 108 also receives the instantaneous vehicle speed from the speedometer unit 114. Using the techniques described above, the processor unit 108 will be able to determine the mass of the object which has been impacted. Thus the processor 108 acts as an evaluator, to evaluate the output of the sensor, in combination with the determined stiffness of the foam at the point of impact, to calculate the mass of the object involved in the impact. If the mass is above a predetermined threshold, an output signal will be passed to the AND-gate 109. Unless the AND-gate 109 is inhibited by a signal on the line 118, which will only be present if the accelerometer 115, the integrator 116 and the discriminator 117 have determined that an impact has occurred with a very heavy object, such as another vehicle, then the control signal will pass from the AND-gate 109 to the safety arrangement intended to provide protection for a pedestrian will be activated.

From the forgoing it will be clear that a sensor, such as an accelerometer or force sensor mounted at the front of a vehicle could be used for discriminating both lighter objects and heavier objects, but is more suitable for

discriminating lighter objects as the sensor might be damaged by an impact with a heavy or very rigid object. It is to be understood that a pedestrian protection device of the type in which the hood or bonnet is lifted, should not be activated in a severe crash as, in such a severe crash situation the hood might penetrate the windscreen. Thus it is desirable for a detector which is an embodiment of the invention to provide the output signal when an impact is sensed, but only if the impact is with an object which has a mass above a predetermined threshold and only if the impact is not part of a severe crash situation.

Thus the preferred arrangement in accordance with the invention will generate a control signal when appropriate conditions exist unless the output signal from the chassis-mounted accelerometer 115 is such that an indication is given that the vehicle has been subjected to a severe crash or accident situation.

In the present Specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".

CLAIMS:

1. An impact detector system for detecting an impact and generating an output signal to activate a pedestrian protection device on a motor vehicle, the system comprising at least one sensor to be mounted at the front of a vehicle to detect an impact, and an evaluator to evaluate the output of the sensor and to generate an output signal when pedestrian detection criterion is fulfilled, the system incorporating an accelerometer to provide a signal indicative of the total deceleration applied to the vehicle, the system incorporating an inhibitor to inhibit generation of the output signal if the signal from the accelerometer fulfills an inhibiting criterion.

2. An impact sensor according to Claim 1, wherein said accelerometer to provide a signal indicative of the total deceleration is located at a substantially central location on the vehicle.

3. An impact sensor according to Claim 1 or Claim 2, wherein the inhibiting criterion is fulfilled when a sliding-window mean value of the signal provided by the accelerometer exceeds a predetermined value.

4. An input sensor according to Claim 1 or Claim 2, wherein said inhibiting criterion is fulfilled when the integrated value of the signal provided by the accelerometer exceeds a predetermined value.

5. A system according to any preceding Claim 1, wherein the sensor is configured to sense a variable that is dependent upon the nature of an impact, the sensor being mounted on or within an element adapted to be mounted on the front of a motor vehicle, the element having a deformable part with a predetermined stiffness, positioned to be deformed during an impact, the stiffness varying in accordance with at least one parameter, the detector incorporating an arrangement to measure the said at least one parameter, the said evaluator being configured to evaluate the output of the sensor in combination with a degree of stiffness corresponding to said at least one parameter as measured, and to generate said output signal when a predetermined threshold is exceeded.

6. A system according to Claim 5, wherein the sensor is a force sensor.

7. A system according to Claim 6, wherein the sensor comprises at least one accelerometer mounted to the element, the element being provided with yieldable supports by means of which the element may be mounted on the front of a motor vehicle.

8. A system according to Claim 7, wherein the sensor comprises two said accelerometers, and wherein the element is provided with two said yieldable supports, each accelerometer being provided located on or in a responsive yieldable support.

9. A system according to Claim 8, wherein the sensor comprises an elongate sensor mounted within the element, the sensor being located to have a force applied thereto when the deformable part of the element is deformed.

10. A system according to Claim 9, wherein the sensor is a piezo-electric cable.

11. A system according to Claim 10, wherein there are a plurality of piezo-electric cables.

12. A system according to Claim 11, wherein piezo-electric cables partially overlap each other.

13. A system according to Claim 9, wherein the sensor is at least one pressure tube.

14. A system according to Claim 13, wherein there are a plurality of pressure tubes.

15. A system according to Claim 14, wherein the pressure tubes partially overlap each other.

16. A system according to any one of Claims 13 to 15, wherein each pressure tube is of non-uniform cross-section, having part of the cross-section of substantial vertical extent and part of the cross-section of lesser vertical extent.

17. A system according to any one of Claims 13 to 16, wherein each pressure tube is provided with a vent hole.

18. A system according to any one of Claims 5 to 17, wherein the deformable part of the element is formed of a deformable foam material.

19. A system according to Claim 18, wherein the element incorporates a substantially rigid beam, the foam being mounted to the beam.

20. A system according to any one of Claims 5 to 19, wherein the element is provided with at least one contact sensor, the detector including a logic arrangement so that said output signal is generated only when an output is provided by the evaluator and an output is provided by the said contact sensor.

21. A system according to any one of Claims 5 to 20, wherein said at least one parameter comprises the thickness of the deformable part of the element, the deformable part of the element being of non-uniform thickness.

22. A system according to Claim 21, wherein the arrangement to measure said at least one parameter comprises an arrangement to measure the point of impact and to determine the thickness of the said element in accordance with the point of impact.

23. A system according to Claim 22, as dependent upon Claim 7, wherein the means to measure the position of impact comprise an arrangement to compare the accelerations imparted to the two accelerometers, and to perform an algorithm.

24. A system according to Claim 22, as dependent upon Claim 11, wherein an analyser is provided to analyse signals from different piezo-electric cables to determine which cable or combination of cables is providing the signal, to determine the point of impact.

25. A system according to Claim 22, or dependent upon Claim 14, wherein an analyser is provided to analyse signals from different pressure tubes to determine which pressure tube or combination of pressure tubes is providing the signal, to determine the point of impact.

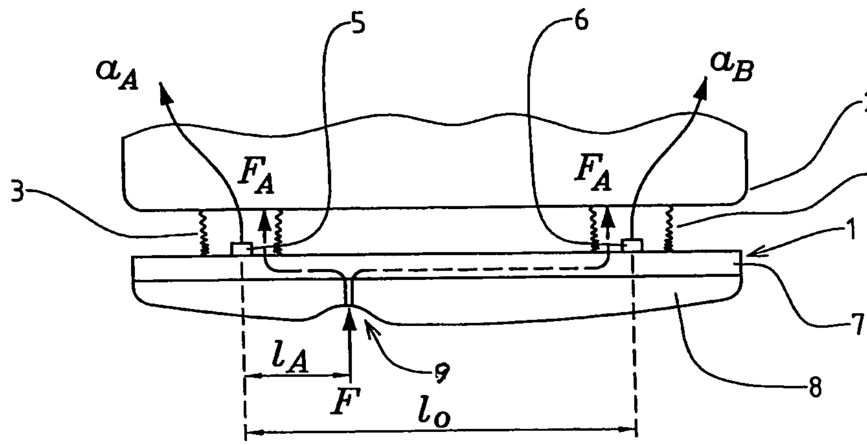
26. A system according to any one of Claims 5 to 25, wherein said at least one parameter includes temperature and wherein at least one temperature sensor is provided to sense temperature.

27. A system according to Claim 26, wherein a plurality of temperature sensors are provided.

28. A system according to Claim 27, as dependent upon Claim 21, wherein the identity of the temperature sensor or temperature sensors providing an output signal used by the evaluator is determined by the means that determine the point of impact.

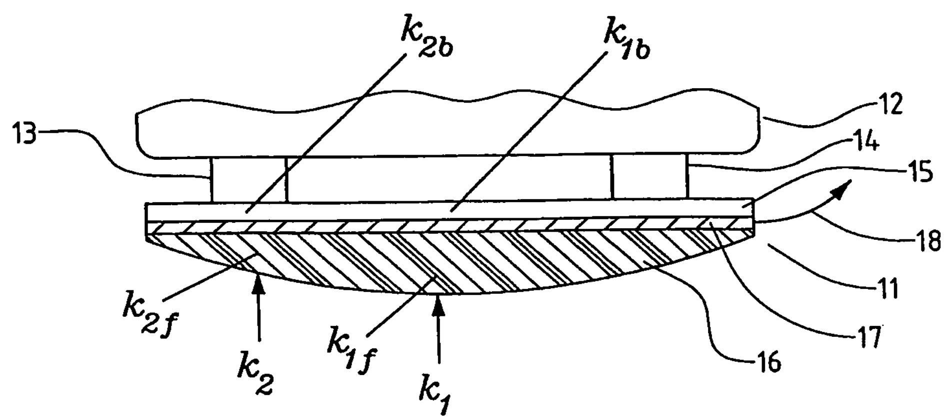
29. A system according to any one of Claims 5 to 28, wherein the evaluator is configured additionally to evaluate a signal indicative of vehicle speed before the impact, the evaluator being configured to generate said output only when the vehicle speed is in excess of a first relatively low threshold and below a second relatively high threshold.

30. A system according to Claim 28, wherein the first threshold is 20 km per hour and the second threshold is 60 km per hour.



a_A
5
6
a_B
2
F_A
F_A
3
4
1
7
l_A
9
8
F
l_o

FIG 1



k_{2b}
k_{1b}
12
13
14
15
18
11
k_{2f}
k_{1f}
k_2
k_1
17
16

FIG 2

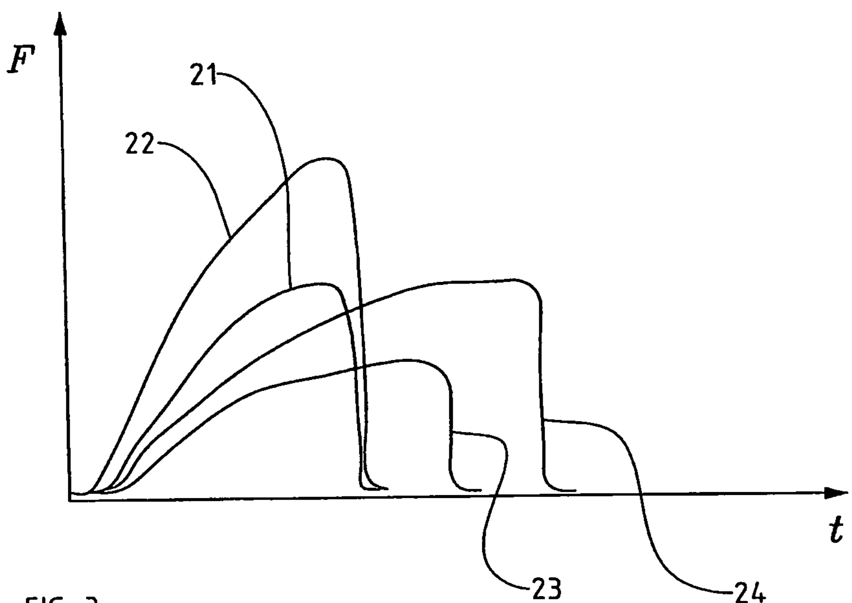


FIG 3

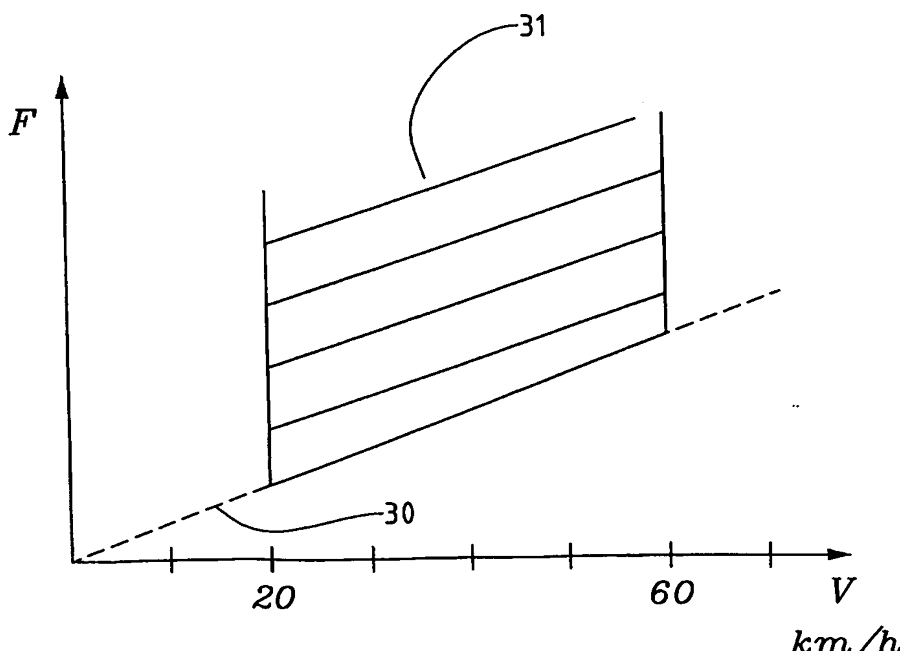


FIG 4

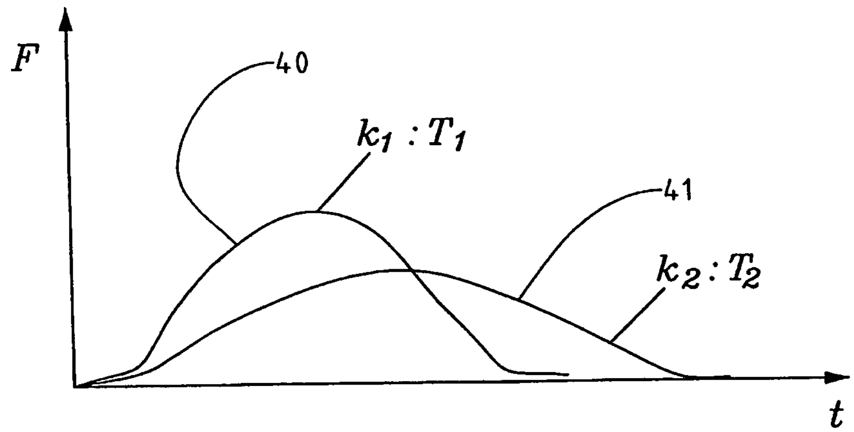


FIG 5

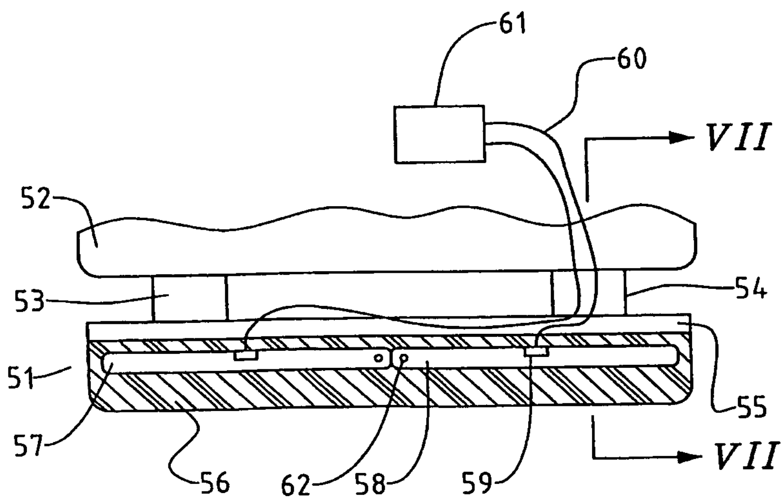


FIG 6

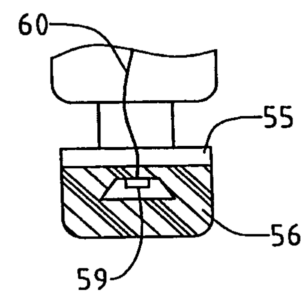


FIG 7

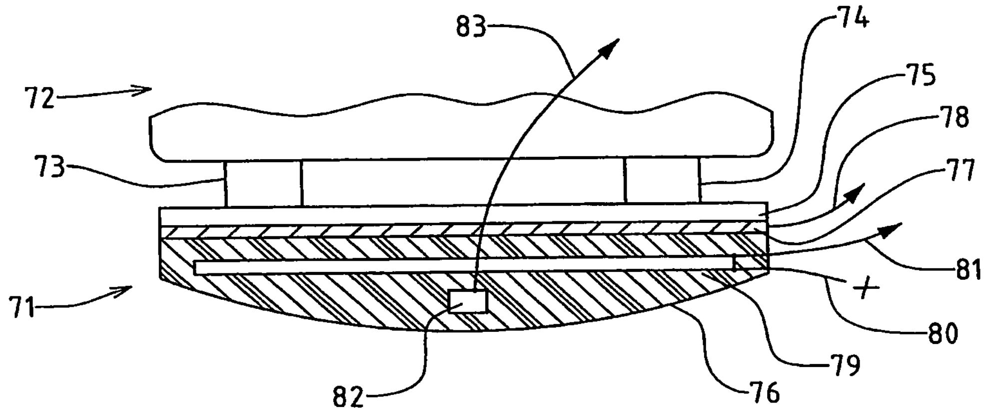
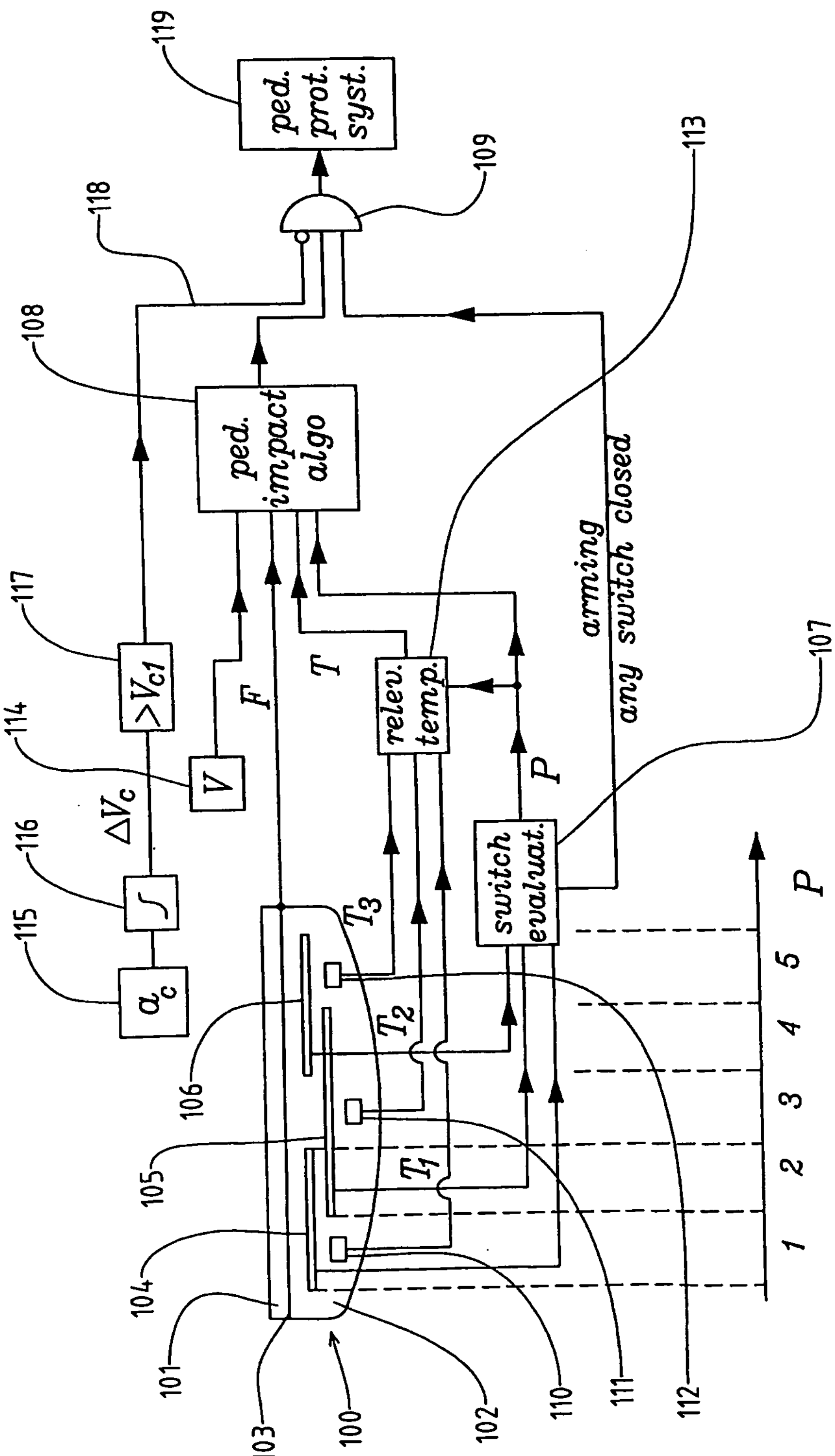


FIG 8


ped. prot. syst.
ped. impact algo
arming any switch closed
relev. temp.
switch evaluat.
>Vc1
ΔVc
V
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T
P
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FIG 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 03/00441

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B60R 21/34
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10030465 A1 (ROBERT BOSCH GMBH), 3 January 2002 (03.01.02), column 2, line 60 - column 5, line 2 --	1-3
A	DE 10045698 A1 (HONDA GIKEN KOGYO K.K.), 17 May 2001 (17.05.01), column 2, line 16 - line 48 --	1-30
A	GB 2356076 A (FORD MOTOR COMPANY LIMITED), 9 May 2001 (09.05.01), page 5, line 26 - page 6, line 29, abstract -- --------	1-30

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 June 2003	16 -06- 2003
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Irma Bornhede /OGU Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 03/00441

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